REPORT OF THE

OFFICE OF THE AUDITOR GENERAL

TO THE

JOINT LEGISLATIVE AUDIT COMMITTEE

239.2

EQUITY OF HIGHWAY USER TAXES

JUNE 1976

Joint Legislative Audit Committee

OFFICE OF THE AUDITOR GENERAL

California Legislature

June 21, 1976

Senator James Mills
President pro Tempore
State Capitol, Room 5100
Sacramento, California 95814

Dear Senator Mills:

In your letter of July 18, 1975 you request an examination of the feasibility of imposing a ton-mile tax. We are pleased to forward the report of the Auditor General of June 16, 1976.

Cordially,

MIKE CULLEN
Chairman

CLARE BERRYHILL
Vice Chairman

MC:CAH:lh
Encl.

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SUMMARY

The last significant change in highway user taxes was the 1961 gasoline tax increase of one cent per gallon. At that time, California's financial support of its highway program was close to the national average. Since then, California support has declined to the lowest amount per vehicle of all the states.

In comparison to other states, California recovers a disproportionately large part of total costs from the owners of small vehicles and a correspondingly small part from large vehicles (page 5). If California were restored to its historic position among the states regarding highway support by increasing the rates of existing taxes, the following problems would result (page 11).

- Increasing fuel tax rates would shift a larger part of the total road costs to small vehicle owners. California owners of automobiles and other small vehicles pay total fees and taxes close to the national average; but these amounts for large vehicles are substantially below amounts paid in other states. In Oregon, the largest truck is assessed approximately $2,600 more than is paid in California for the same number of miles of operation.

- Increasing the weight fees would shift a greater burden to the least-used vehicles, because mileage is not a factor in the amount of tax.

Seven states overcome these problems by levying a weight-distance tax on large vehicles (page 13). Any of the three forms of this tax could be levied in California. Ohio's axle-mile tax is the easiest and least costly to administer, and enables the greatest improvement in equity among the owners of the various types of vehicles.

Our recommendation (page 16) requires legislative action to improve the equity of the California highway user tax system.

INTRODUCTION

In response to a legislative request, we reviewed the equity of the group of taxes imposed on the ownership and use of motor vehicles. These taxes are known collectively as "highway user taxes." Our objective was to determine the fairness of the payments made by different road users and to identify means by which the equity of the tax system may be improved. Information from records, reports, interviews and observations, including data from other states and federal agencies, was analyzed; however, conventional audit procedures were not applied, as this review is not an audit by nature.

The study's scope has also been limited to the equity of the distribution of state highway taxes among highway users. The important but independent issue of the tax burden between users and nonusers was not reviewed. For purposes of this study, California's user taxes include motor fuels taxes, vehicle registration and weight fees, and drivers' license fees. California's "in-lieu" property tax on vehicles actually acts as a means of collecting and allocating local property taxes, but is charged to vehicle owners statewide. Where possible, both the effects of user taxes and those including "in-lieu" taxes were reviewed.

We appreciate the cooperation and assistance of the staff of the Department of Transportation and those of other states' governments, especially Ohio's Department of Taxation.

History of Highway User Taxes

In 1901, motor vehicle registration fees were introduced in New York. By 1905, 25 states levied such user taxes. In 1919, Oregon introduced gasoline taxes. By 1929 all states levied a tax on motor fuels. Since then, user taxes have acquired an established and accepted position as the primary sources of highway finance.

California implemented a user tax system in 1923 when general bond proceeds alone could not finance desired highway programs. A motor fuel tax of two cents per gallon was established, half to support state highway programs and half subvened to cities and counties. A $3 registration fee for all vehicles was also established to cover titling and recordkeeping costs for each vehicle. Considering the greater construction and maintenance cost responsibility of trucks, commercial vehicles were charged an additional flat fee based on unladen weight. For-hire carriers were taxed a percentage of their gross receipts in recognition of the greater "profit" they derived from highway use. Except for the elimination of the gross receipts tax, these tax mechanisms remain the basis of California's highway user revenues.

Major increases in California's highway user tax rates have generally accompanied major expansion in the street and highway program; temporary gasoline tax increases have also been authorized to pay for emergency storm damage repairs. Other than rate increases, the only substantial change came in 1973 when the gross receipts tax on for-hire vehicles was abolished. Unladen weight fees on commercial vehicles were increased an average of 30 percent to compensate for the loss of gross receipts tax revenues.

Highway user tax revenues were responsible for $1.099 billion, or 77 percent of the funds flowing to the California Motor Vehicle Account in fiscal year 1973-74. The sources are indicated in the following table.

CALIFORNIA HIGHWAY USER TAX REVENUES
1973-74

Source	Revenues (Millions)	Percent of User Tax Revenues
Motor Vehicle Fuel Taxes	$ 757.6	68.9%
Vehicle Registration Fees	197.3	18.0
Commercial Vehicle Weight Fees	106.6	9.7
Drivers' License Fees	14.3	1.3
Miscellaneous Taxes and Fees	23.5	2.1
Total User Tax Revenues	$ 1,099.3	100.0%
Motor Vehicle License Fees ("in-lieu" property taxes)	315.0	
Miscellaneous Income	9.6	
Total, Motor Vehicle Account	$ 1,423.9	

Fuel taxation is the most important source of both user tax revenues and those in the total Motor Vehicle Account. Excluding "in-lieu" property tax levies, the next most important revenues are vehicle registration and commercial vehicle weight fees, which accounted for 27.7 percent of user tax revenues in fiscal year 1973-74.

FINDING

EXISTING HIGHWAY USER TAXES DO NOT EQUITABLY RECOVER COSTS

California owners of motorcycles, automobiles and light trucks pay total fees and taxes which are close to the national average, but large truck operators pay substantially less in California than in other states. These underpayment amounts are proportional to vehicle size. For example, total fees and taxes paid in Oregon for a large truck are $2,600 more than is paid in California for the same number of annual miles of vehicle operation.

Fairness of Tax System

Little insight in the relative fairness of a state's highway tax system is provided by comparisons of the State's gasoline and other highway user tax rates to other states because a lower rate for one tax may be offset by a higher rate for another tax. The comparative total amounts of all user taxes paid by the various road users evidences the relative equity of the tax system. The soon-to-be-completed cost responsibility study being conducted by the Department of Transportation will further show the relative fairness of the tax system.

For many years Oregon has used highway user cost responsibility studies to evaluate and modify its user tax structure to equitably tax users according to each user's responsibility for the highway system.

The rationale for the Oregon system is as follows. If the road system accommodated only vehicles of a single size, the system would be visually and structurally different. From this, Oregon has concluded that the owners of smaller vehicles should only be taxed to pay the cost of constructing and operating the facilities as they would exist if their vehicles were the largest vehicles. No vehicle owners should be forced to contribute to the cost of larger and structurally more complicated facilities than is necessary to accommodate their vehicle size and weight. The cost responsibility for each of the major vehicle sizes is established by engineering analysis, and the tax system designed and tax rates set to recover such costs. Oregon levies a weight-distance tax on large vehicles to recover their assigned cost responsibility amounts which are not recovered through fuel taxes or weight fees.

Two types of comparisons of California and other states' user taxes are made. First, the total taxes paid in California for each of 25 vehicle types from motorcycle to the largest truck are compared to the average amount paid in all states for the same number of annual miles of operation. This comparison shows only how much California departs from the national average. Second, the same comparisons are made to the average taxes paid in Oregon and the other states which have weight-distance taxes in their tax systems.

The information to make such comparisons is compiled by the Federal Department of Transportation for 25 vehicle types ranging from motorcycles to a 76,000-pound gross weight, diesel-powered, truck-trailer combination. The most recent study is of the tax rates in effect on January 1, 1973. Since this date, the following changes have been made

in California user taxes:

- The motor vehicle transportation tax levied on the gross receipts of intercity motor carriers was abolished

- Weight fees on small trucks were reduced while the fees on larger vehicles were increased an average of 30 percent.

The following comparisons reflect these changes.

California Compared to All Other States

The following table compares the total fees and taxes paid in California to the average of other states for the same average annual mileage. Only four relatively small vehicles are assessed higher fees in California. For the other 21 vehicles, the amounts of underassessment generally increase as the size of the vehicle increases.

ANNUAL ROAD USER FEES AND TAXES
CALIFORNIA COMPARED TO AVERAGE OF OTHER STATES

Vehicle Type	Total Fees and Taxes Per Vehicle: Other States' Average	California	California Over	California Under
Motorcycle	$ 21.28	$ 26.30	$ 5.02	
Very light passenger car	73.13	68.00		$ 5.13
Medium weight passenger car	110.46	105.47		4.99
Heavy passenger car	166.78	159.06		7.72
47-seat diesel-powered bus	2,042.55	1,886.09		156.46
Pickup truck, 5,000 pounds:				
Private operation	112.88	116.40	3.52	
Farm service	79.35	94.56	15.21	
Stake truck, 14,000 pounds:				
Private operation	220.87	220.24		.63
Carrier	309.84	286.11		23.73
Farm service	114.53	160.32	45.79	
Van truck, 24,000 pounds:				
Private operation	489.31	486.91		2.40
Carrier	692.21	546.52		145.69
Diesel, 3-axle, 50,000 pound dump truck	1,004.86	993.55		11.31
Gasoline, 3-axle tractor, semitrailer, 40,000 pounds:				
Private operation	984.35	882.69		101.66
Carrier	1,241.86	1,038.23		203.63
Gasoline, 4-axle tractor, semitrailer, 55,000 pounds:				
Private operation	1,714.76	1,484.60		230.16
Carrier	2,025.03	1,659.60		365.43
Diesel, 4-axle tractor, semitrailer, 55,000 pounds:				
Private operation	1,484.02	1,263.97		220.05
Carrier	1,742.72	1,391.23		351.49
Diesel, 5-axle tractor, semitrailer, 72,000 pounds:				
Private operation	2,276.55	2,002.42		274.13
Carrier	2,391.43	2,002.42		389.01
Diesel, 5-axle tractor, semitrailer, with full trailer, 72,000 pounds:				
Private operation	2,630.07	2,028.59		601.48
Carrier	2,761.85	2,028.59		733.26
Diesel, 5-axle truck and full trailer, 76,000 pounds:				
Private operation	3,080.26	2,332.64		747.62
Carrier	3,298.12	2,332.64		965.48

California Compared to Weight-Distance Tax States

The table on the following page compares the fees and taxes paid in California to the average of those states which have weight-distance taxes in their highway user tax system. These states are Colorado, Idaho, New Mexico, New York, Ohio, Oregon and Wyoming.

This comparison shows that California, with only minor exceptions, overcollects from all smaller vehicles and undercollects from all larger vehicles. The smaller vehicle overcollections range up to $73 per year, while the undercollections from large vehicles exceed $1,800 per year.

ANNUAL ROAD USER FEES AND TAXES
CALIFORNIA COMPARED TO MILEAGE-TAX STATES

Vehicle Type	Total Fees and Taxes Per Vehicle: Other States' Average	California	California Over	California Under
Motorcycle	$ 13.64	$ 26.30	$12.66	
Very light passenger car	55.95	68.00	12.05	
Medium weight passenger car	86.89	105.47	18.58	
Heavy passenger car	115.22	159.06	43.84	
47-seat diesel-powered bus	2,037.85	1,886.09		151.76
Pickup truck, 5,000 pounds:				
Private operation	90.93	116.49	25.47	
Farm service	62.12	94.56	32.44	
Stake truck, 14,000 pounds:				
Private operation	190.42	220.24	29.82	
Carrier	276.62	286.11	9.49	
Farm service	87.31	160.32	73.01	
Van truck, 24,000 pounds:				
Private operation	418.86	486.91	68.05	
Carrier	648.24	546.52		101.72
Diesel, 3-axle, 50,000 pound dump truck	924.72	993.55	68.83	
Gasoline, 3-axle tractor, semitrailer, 40,000 pounds:				
Private operation	1,011.95	882.69		129.26
Carrier	1,373.75	1,038.23		335.52
Gasoline, 4-axle tractor, semitrailer, 55,000 pounds:				
Private operation	2,175.12	1,484.60		690.52
Carrier	2,568.90	1,659.60		909.30
Diesel, 4-axle tractor, semitrailer, 55,000 pounds:				
Private operation	1,950.73	1,263.97		686.76
Carrier	2,295.91	1,391.23		904.68
Diesel, 5-axle tractor, semitrailer, 72,000 pounds:				
Private operation	3,344.98	2,002.42		1,342.56
Carrier	3,349.26	2,002.42		1,346.84
Diesel, 5-axle, tractor, semitrailer, with full trailer, 72,000 pounds:				
Private operation	3,881.20	2,028.59		1,852.61
Carrier	3,886.20	2,028.59		1,857.61
Diesel, 5-axle truck and full trailer, 76,000 pounds:				
Private operation	4,040.73	2,332.64		1,708.09
Carrier	4,044.06	2,332.64		1,711.42

Achieving Tax Equity

In effect, a user tax system is a pricing structure for a public service. It is intended to achieve equity among all users. (A detailed and theoretical discussion on the equity of highway taxation is Appendix I of this report.) If all vehicles were essentially the same size and weight, a single tax, such as the fuel tax, could be equitable. The benefit derived from road facilities is proportional to usage, and fuel consumption would be a good measure of usage if all vehicles were the same size and consumed the same amount of fuel per mile. But vehicles are not the same size, and the following two conditions cause all states and the federal government to levy additional fees on large vehicles.

First, a significant part of the total costs of roads is incurred because of larger vehicles. Second, larger vehicles are more efficient in that less fuel is consumed per ton of weight moved. A loaded truck may weigh 20 times more than a mid-size sedan but consume only three to four times more fuel per mile of operation. Therefore, even if no additional facilities costs were attributed to heavier vehicles, the substantial differences in vehicle efficiency would result in material inequity if fuel taxes were the only users' charge.

Increasing weight fees would cause large inequities among individual owners of large vehicles. Recovering the underassessment amounts shown on the prior page by increasing annual weight fees would cost the owner of a large truck operated 75,000 miles only two cents per mile; the added cost for a similar truck operated 10,000 miles would be 17 cents per mile.

The last significant increase in California road user taxes was the 1961 increase of one cent per gallon in the gasoline tax. At that time, the state expenditure per registered vehicles for highway purposes was close to the national average: $79.95 per vehicle in California and $84.76 average for all other states. Since that time California highway support has declined. In 1973, the most current year comparative amounts are available for all states, California expended the least amount of all the states: $59.01 per vehicle in California compared to an average of $100.08 in all other states.

The decline from a position near the national average to the lowest level of support of all the states results from either (1) a policy of reduced state highway support in contrast with the growing support in other states, (2) the inability to develop the necessary support to maintain the State's historic position among the states or (3) California's unfulfilled needs have been reduced below other states. In any case, increasing existing tax rates would result in greater inequities among road users because of the following.

- Annual weight fees do not consider road usage; therefore, low users pay as much as high users.

- Fuel tax rates, if increased, would minimally reduce the large vehicle underpayments but substantially increase the small vehicle overpayments. The reason for this is the variation in efficiency by vehicle size, which is shown in Appendix II on page 26.

Weight-Distance Tax

Seven states employ one of the three major forms of highway weight-distance taxes, and their combined 217 years of experience is instructive. Colorado and Wyoming have flat "ton-mile" rates per mile. Idaho, New Mexico, New York, and Oregon employ graduated "weight-mile" tax rates which vary with gross vehicle weight. Ohio charges various "axle-mile" rates based on the visual classification of vehicles with more than two axles. All three of these types of systems require affected vehicle operators or owners to submit monthly or quarterly mileage reports and tax payments. Tax administrators and state police conduct spot verifications of vehicle tax status and actual mileage to enforce accurate reporting. Appendix III describes the differences in the three types of taxes.

The advantages of the axle-mile tax over other forms of weight-distance taxes are as follows:

- The equity improvement is superior because the tax system incorporates a larger number of vehicle cost-responsibility characteristics

- Greater simplicity results because fewer vehicle classes are necessary for tax purposes

- This is the easier tax to administer because trucks need not be weighed.

- This tax costs less to enforce and administer.

Implementing an Axle-Mile Tax in California

The average annual mileage does not vary significantly for vehicles weighing less than about 26,000 pounds gross. However, among heavier vehicles there are substantial mileage variations. U. S. Census Bureau data indicate the following pattern of truck mileage by gross weight category. The average annual mileage of automobiles is about 10,000 miles.

AVERAGE, ANNUAL, CALIFORNIA TRUCK MILEAGE BY GROSS WEIGHT CATEGORY

Category by Laden Weight	Average Annual Miles
10,000 pounds and under	11,400
10,001 to 20,000 pounds	13,700
20,001 to 26,000 pounds	14,300
over 26,000 pounds	41,600

The relatively small deviation in average annual mileage below 26,000 pounds, compared with the average mileage of heavy trucks, suggests that equity considerations can be resolved through existing taxes for light vehicles.

The 26,000-pound threshold is also convenient for an axle-mile tax, since this tends to be the maximum operating gross weight of two-axle vehicles. Few two-axle trucks weigh more than 26,000 pounds, and only eight percent of trucks with more than two axles weigh less than 26,000 pounds. Axle-mile taxes should therefore be required of all vehicles with more than two axles. Approximately one percent of vehicles registered, or about seven percent of trucks, should then be subject to the axle-mile tax in California.

The State of Ohio imposes the following tax rates in addition to fuel and weight fees similar to California.

Type of Vehicle	Rate per Mile
Commercial vehicle with three or more axles	1/2¢
Commercial tandem with three axles or a commercial tractor operated as part of a commercial tractor combination with three axles	1¢
Commercial tractor operated as a part of a commercial tractor combination with four axles	1-1/2¢
Commercial tractor operated as part of a commercial tractor combination with a total of five or more axles	2¢
Commercial vehicle or commercial tractor operated as part of a commercial tandem with four or more axles	2-1/2¢

The axle-mile tax applies to vehicles whether they are used in a for-hire operation or for private transportation.

CONCLUSION

Compared to other states, California owners of small vehicles pay a larger share of highway user taxes, and heavy trucks pay a lower share. By implementing a tax on large vehicles which considers miles of travel and weight exerted on the road facilities, these disparities can be reduced. Implementation of the Ohio axle-mile tax is the most effective and economical means of reducing the California disparity.

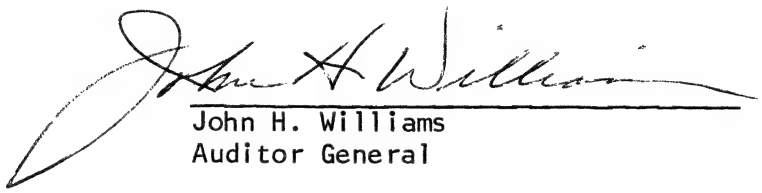
RECOMMENDATION

We recommend that the Legislature incorporate into the highway user tax system an axle-mile tax on vehicles with more than two axles, similar to that levied by the State of Ohio.

BENEFIT

Implementation of this recommendation would improve equity of the California highway user tax system.

Respectfully submitted,



John H. Williams
Auditor General

June 16, 1976

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HIGHWAY TAXATION AND EQUITY

PRINCIPLES

A large body of theoretical and analytical literature has developed on highway taxation, evolving toward a consensus of professional opinion on certain principles for evaluating the equity of highway taxes. The following reflects our interpretation of the logic of highway user taxation.

Public finance theory encourages taxation according to the principle that taxes should be borne according to benefits received. In addition to promoting an equitable tax structure, this "benefit principle" tends to efficiently allocate government services according to beneficiary demand. Waste is minimized because beneficiaries will tend not to use services whose costs exceed expected benefits.

The amenability of different government services to application of the benefit principle is logically responsible for distinctions in their methods of finance. "Collective goods" benefit all citizens according to some probably unmeasurable pattern. Some benefits of highway services are collective in this sense. All citizens benefit from both their own increased mobility and that of the entire society. Financing the collective benefits of government services has traditionally relied on taxation of indirect benefits, such as the enhancement of property values, or on other criteria than the benefit principle, such as "ability to pay."

The fact that the primary benefits of highways are not collective permits highway finance to be more directly aligned with the benefit principle. Motor vehicle owners and operators are the intended and actual primary beneficiaries of roads and highways. Furthermore, taxing highway use is convenient because access to such services can be controlled. The most common sanctions are use permits (drivers' licenses and vehicle registrations) and use fees (fuel taxes and tolls).

Such "user taxes" are also capable of assessing at least a portion of the collective highway benefits received by all citizens. Even nonusers must pay for goods and services whose values are enhanced by highway transport or access. To the extent that all citizens pay for the imputed and transferred value of highways in the prices of all goods consumed, user taxes effectively assess collective highway benefits. (General property, sales, and income taxes are commonly used to assure that collective benefits are completely assessed. California's "in-lieu" property tax on vehicles is an example of such an effort in highway finance.)

THE EQUITY OF HIGHWAY USER TAXES

Determining the equity of a user tax structure involves comparing the distribution of user tax burden with that of user benefits. Two approaches can measure user benefits. The first is "value of service," the value an individual user receives from his highway use. The

practical difficulties of measuring highway value to users and of assigning dollar amounts to such values preclude reliance on this approach as a basis for taxation. The second approach of "costs occasioned" simplifies the establishment of an equitable highway user tax structure. The highway construction, maintenance, and administration costs occasioned by each user are surrogates for the benefits he receives from use, much as the costs of producing a product are surrogates for consumer benefits. Such costs are more amenable to pricing or assigning dollar value to benefits received than attempting to measure benefits directly. An equitable and feasible highway user tax structure can thus be based upon individual user cost responsibility for the highway network he uses.

The benefit principle does not require that all benefits be recaptured, but that the financial burden be distributed in proportion to benefits. Highway benefits may exceed government costs of highways provision, but as long as the tax burden is proportional to benefits, any beneficiary "profits" will be similarly proportional.

An analysis of the distribution of highway user cost responsibility is thus appropriate to practical determination of the equity of the user tax structure. For purposes of analysis, users can be categorized according to the vehicles used. The vehicle is the relevant design unit which highway engineers must consider, and the different classes of vehicles have different design requirements and different cost responsibilities. Engineering studies such as the Department of

Transportation's current effort can provide estimates of the design and maintenance cost requirements of each vehicle category. By weighing these requirements by each vehicle category's portion of total highway use, estimates can be made of relative user cost responsibility by vehicle category. The user tax structure can then be designed (or evaluated) to apportion each user's share of the total cost responsibility of his vehicle.

APPROACHES TO HIGHWAY USER COST ALLOCATION

There are four basic approaches to determining the distribution of highway user cost responsibility:

1. Differential Benefits Method
2. Gross-Ton-Mile Method
3. Incremental Method
4. Cost-Function Method

All but the differential benefits and gross-ton-mile methods are based on the concept of "costs occasioned" as a surrogate for user benefits. As noted above, the practical difficulties of measuring benefits and assigning dollar value to them precludes convenient use of the differential benefits method. The gross-ton-mile approach has been used both to measure benefits and costs occasioned, so it may be compared with the two purely costs-occasioned approaches.

The "costs occasioned" approaches are distinguished primarily by a tradeoff between conceptual simplicity and theoretical rigor. The gross-ton-mile method is the simplest of the three methods, but its logic bears the least relation to principles of highway user cost responsibility. On the other hand, the incremental approach requires the most sophisticated data and calculations of the "costs occasioned" approaches; the incremental method also yields the most sophisticated results. The cost-function approach attempts to simplify the data requirements of the incremental theory with a minimum sacrifice in theoretical sophistication. The following discussion describes each of these approaches and each approach's relative merits.

The Gross-Ton-Mile Method

The gross-ton-mile approach assures that road facilities are provided for joint use by mixed traffic, and that the costs occasioned and benefits derived by users are essentially joint. Therefore, highway costs should be apportioned among the various vehicle classes according to relative use, multiplying gross vehicle weight times distance traveled. This measure oversimplifies both benefits and costs occasioned from highway use. Gross vehicle weight is an arbitrary unit for measuring highway benefits; gross weight has no necessary relation to the economic or personal value derived from highway.

The gross-ton-mile method does appear to compensate for the differential costs incurred in providing highway facilities for the heavier types of vehicles, but does so without great pretense of accuracy.

Neither the required thickness nor the required cost of a road surface varies directly with the gross load factor. The wheel or axle load of a vehicle, and not the gross load, is the major element in estimating relative thickness of road surface required for vehicles of different types and weights. Thus, highway engineers consider the weight placed upon individual axles and not vehicle gross weight in designing road surfaces. An example of this may be seen in the comparison of two trucks; one truck with two axles of 8,000 and 18,000 pounds (and a gross weight of 26,000 pounds), and another truck combination with five axles of comparable unit weight and gross weight of 72,000 pounds. The small vehicle having one 18,000-pound axle load requires the same standard of highway design (with the possible exception of structure design) as the larger vehicle which has two tandem axles weighing 32,000 pounds per tandem. The two trucks have vastly different gross weights, but the axle weights are comparable. If the rear axle of the smaller truck were to carry 26,000 pounds, it would require higher design standards and thus a more costly facility than the larger vehicle even though its gross weight would only be 34,000 pounds. In this case, the larger truck could be operated over roads of lower strength than required for the smaller truck and not inflict as much damage on these facilities. The gross-ton-mile method does not properly allocate weight-related highway costs.

In addition to weight-related costs there are other highway costs that are not related to gross weight. The ton-mile unit does not apply to elements of highway costs which in no way support the load, such as road signs, traffic signals, right-of-way, police enforcement, and highway administration.

In conclusion, the gross-ton-mile approach's theoretical oversimplification of the relationships between vehicle characteristics and highway costs or benefits nullifies the advantages inherent in its simplicity.

The Incremental Approach

A superior approach to allocating user responsibility for highway costs is the incremental theory, which recognizes that highways are designed for mixed traffic and for special vehicles' characteristics, such as heavy loads, large size, etc. Thus, there are costs for which all vehicles share responsibility and separable costs allocable to only some vehicles. For example, one cannot add two inches of pavement thickness to a 10-inch pavement unless the 10 inches are already there. Similarly, extra lanes cannot be added unless lanes are already in place. Users who may be responsible for added costs have responsibility for these initial costs, as well as for the added costs for which they alone are responsible. In short, one has to deal not only with the truly separable costs but with an assignment of costs of all earlier increments, costs that will be common to more than one class of vehicles.

The incremental theory approaches cost responsibility in the closest analogy to the way engineers approach highway design. The first increment is required by all vehicles, and its cost should be so allocated. Other increments are required only for heavier or larger vehicles, and their costs should be allocated among all except the lightest and smallest class of vehicles. In the case of pavement costs, the appropriate incremental unit is axle weight; the pavement cost of each successive increment is distributed among the progressively smaller number of axles that require it. This concept applies to all weight and size-related elements of highway cost, even though other vehicle characteristics may be appropriate for cost items other than pavement. Highway costs not related to a vehicle size or weight, such as those for road signs, policing and administration, should be allocated nonincrementally according to vehicle mileage or the number of registered vehicles.

The Cost-Function Method

This method was developed as a variant of the incremental approach which required much less data and calculations with a minimum sacrifice in theoretical rigor. The cost-function approach's short-cut is to make assumptions about the essential factors of user cost responsibility which the incremental approach does not take for granted. The cost-function approach categorizes each highway cost element into one of three classes: (1) those that vary with vehicle size, weight, or axle-loading which are allocated according to axle-miles of travel; (2) those that vary with highway use, but not vehicle size, weight, or axle-loading which are

allocated according to vehicle mileage; and (3) those that are not related to vehicle characteristics or use. Carefully applied, this method can yield similar results to the incremental method. However, variations in the relatively arbitrary assignments of certain costs to one of the three categories can have significant effects on the results.

Results from Use of the Different Methods

Each of these three methods tends to produce a particular distribution of user cost distribution. The following table arrays the results from the U. S. Bureau of Public Roads (BPR) study, reported in 1961 and 1965. In each case, the BPR applied a different cost allocation method to the same highway cost and use data.

Bureau of Public Roads Study	Basic Approach	Allocated Per Mile Cost Responsibility for Automobiles (Cents)
1961	Gross Ton-Mile	.204
1961	Cost-Function	.234
1965	Incremental	.322

These results suggest that the more sophisticated the approach, the higher is the responsibility assigned to automobiles. The incremental method therefore tends to be the most conservative in allocating responsibility to heavy vehicles.

The Department of Transportation's current cost allocation study intends to employ the incremental method to the extent practical within the limits of available data.

Average Fuel Efficiency Per Ton Hauled

Vehicle Category	Gross Weight (tons)	Average Fuel Consumption (mpg)	Average Fuel Efficiency per Ton Hauled (ton/mpg)
Automobile			
Compact	1.27	21	.06
Medium Sedan	2.12	14	.15
Large Sedan	2.79	12	.23
Pickup Truck	2.5	12	.21
Medium 2-Axle Stake Truck	4.14	8.5	.49
Medium 3-Axle Van	12.0	4.5	2.67
Tractor and Single-Axle Semi-Trailer Combination (gasoline)	20.0	4.5	4.44
Tractor and Dual-Axle Semi-Trailer Combination (diesel)	27.5	5.5	5.0
Three-Axle Tractor and Dual-Axle Semi-Trailer Combination (diesel)	36.0	4.9	7.35
Tractor, Dual-Axle Semi-Trailer, and Full Trailer Combination (diesel)	36.0	4.9	7.35

Weight-Distance Taxes

The primary differences among the three approaches (ton-mile, weight-mile, and axle-mile), lie in their logic and administrative costs. The straightforwardness of the "ton-mile" approach reflects the simple but questionable assumption of a linear relationship between vehicle weight and user cost responsibility. None of the cost allocation studies has indicated such a linear relationship, and user cost allocation theory suggests that this relationship probably never occurs. Implementing non-linear user cost allocations through a linear ton-mile tax system would therefore be difficult, if not impossible, unless the entire user tax structure (registration fees and fuel taxes) were simultaneously overhauled. Whatever attractiveness the ton-mile approach might have is overshadowed by the large administrative and political costs implied by such implementation problems.

Varying the mileage tax rate according to gross vehicle weight improves the potential feasibility of "weight-mile" taxes over the ton-mile approach. Oregon's weight-mile tax structure, for example, provides 74 different rates according to type of fuel consumed. However, an axle-mile system can provide greater equity than the weight-mile tax at lower administrative cost for both the state and taxpayers.

An axle-mile tax can provide the greatest equity of the three approaches due to the greater number of cost-responsibility-related vehicle characteristics that can be incorporated into an axle-mile tax

than in mileage taxes related solely to vehicle weight. Weight-mile taxes consider only gross vehicle weight, which is only peripherally related to actual factors in weight-related user cost responsibility. Ohio's axle-mile system considers two variables of direct relevance to weight-related cost responsibility: number of axles and vehicle visual classification (e.g., single unit truck, tractor with semi-trailer, truck with full trailer). Additional factors, such as axle load or gross weight, could be incorporated into an axle-mile tax, but the additional administrative complexity is, in our judgment, probably not justified by the resulting marginal increases in equity. Knowing only the number of axles and visual-class of each vehicle, the states can assess user cost responsibility with as much accuracy as we believe is provided by any cost responsibility study.

The axle-mile tax's greater sensitivity to actual weight-related cost responsibility is also responsible for the tax's greater simplicity and lower administrative costs. An axle-mile tax tends to require a less complicated rate structure than do weight-mile taxes. The four states using weight-mile taxation have up to twelve times as many different rates for their numerous classes of gross weight as does Ohio for its axle and visual classifications.

An axle-mile tax would also be less expensive for California to administer than weight-mile taxes, which require verification of actual vehicle weight in addition to vehicle tax status and mileage. If Oregon's weight-mile tax experience is a valid example, eleven times as many truck weight inspection stations as are now operating in California would be

needed to verify the same percentage of trucks' weights as in Oregon. Enforcing an axle-mile tax is also easier because permit violations require only a visual verification, and mileage records are more easily auditable than both weight and mileage reports. Perhaps most important, truck operators or owners are not required to calculate or measure vehicle weight with an axle-mile tax. They simply report the mileage a particular vehicle combination was operated.

As a result of these factors, administrative costs as a percentage of revenues are generally lower in Ohio's axle-mile experience than among either ton-mile or weight-mile states, as the following table indicates.

Seven States' Weight-Distance Taxes
Average Costs and Revenues

	Year Implemented	Total Administrative Costs as Percent of Revenue	Weight-Distance Tax Revenue as Percent of Highway User Revenue
Ton-Mile Tax			
Colorado	1927	10%	13.6
Wyoming	1931	10.5	19.6
Weight-Mile Tax			
Idaho	1952	8.2	12.4
New Mexico		- data unavailable -	
New York	1951	9	5
Oregon	1947	about 5	19
Axle-Mile Tax			
Ohio	1953	3.6	5.6

Ohio's axle-mile tax has cost only 3.6 percent of revenues to administer, a lower percent than that of any of the other states using weight-distance taxes. Ohio's cost rate is especially low considering that Ohio's axle-mile tax generates one of the smallest portions of total highway user revenues among the states using weight-distance taxes. Ohio's administrative costs have also decreased as taxpayers and administrators have acquired greater experience with axle-mile taxation. Administrative costs were only 2.6 percent of axle-mile revenues in fiscal year 1973-74, the most current year for which Ohio cost data are available.